FLAT-TYPE SEMICONDUCTOR DEVICE

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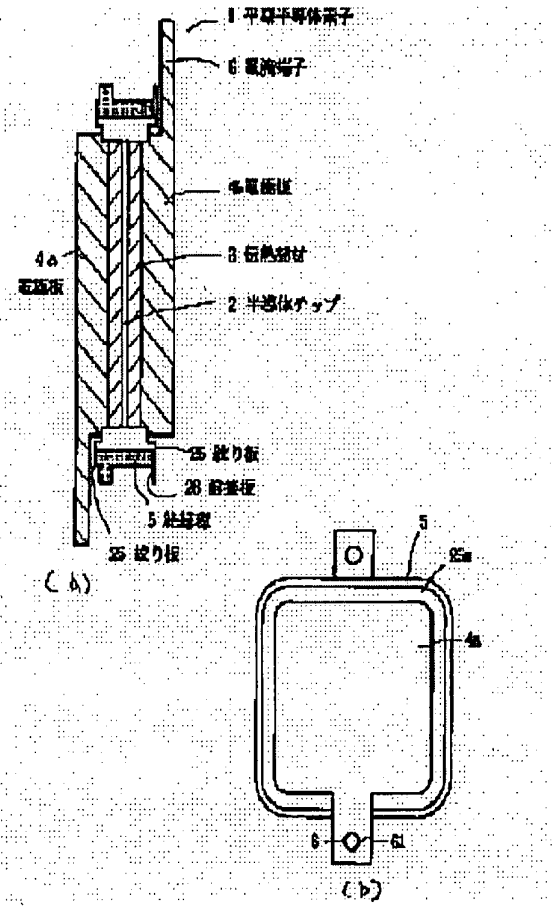
Abstract of **JP9260585**

PROBLEM TO BE SOLVED: To provide a flat-type semiconductor device which enables an electric power control device including a cooling device to be reduced in size and weight by reducing the thermal resistance between the semiconductor device and a coolant when a double-side cooling flat-type semiconductor is used in a circulating water cooling system.

SOLUTION: A plate-like protrusion is provided to the one end of each of the electrode plates 4a and 4b of a flat-type semiconductor device 1 extending outwards beyond the periphery of an insulating ring 5 to serve as a current 6. A usual current plate can be dispensed with, so that a thermal resistance between the current plate and a contact can be eliminated. As compared with a conventional one, a thermal resistance between the flat-type semiconductor device 1 and a coolant can be reduced by 25%. It is preferable that the current terminals 6 are set deviating from each other in position so as not to impede their connection with outer conductors.


1 平型半導体素子
6 電流端子
4a 電極板
3 伝熱部材
2 半導体チップ
25 絞り板
28 耐圧板
5 外装板
25 絞り板
(a)
5
25a
4a
6
6a
(b)

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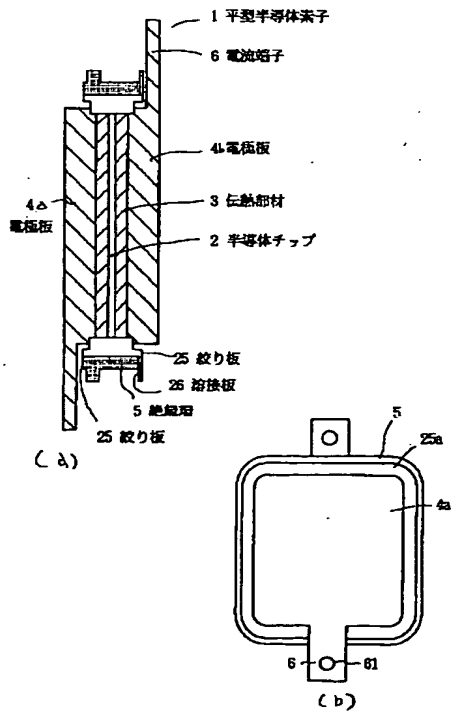
(54)【発明の名称】　平型半導体素子

(57)【要約】
【課題】両面冷却型の平型半導体素子を循環水冷却方式で使用する際に、半導体素子と冷却体間の熱抵抗を低減し、冷却装置まで含めた電力制御装置の形状の小型化、軽量化が図れる平型半導体素子とする。
【解決手段】平型半導体素子１の電極板４の一部を絶縁環５の外周より外側に延長した板状突起を設け、電流端子６として使用する。従来使用していた通電板が不要になり、通電板と接触部一か所の熱抵抗が削減できる。平型半導体素子１と冷却体８間の熱抵抗が、従来に比べ約２５％低減できた。両側の電流端子６が互いに外部導体接続の際の邪魔にならないように、位置をずらして設けるとよい。



【特許請求の範囲】

【請求項１】セラミックの絶縁環に固着された二枚の金属電極板をもち、収納された半導体チップの両側から放熱する両面冷却型の平型半導体素子において、少なくとも一方の電極板の一部が絶縁環の外周より外側に延長された板状突起を有し、その板状突起を主電流端子とすることを特徴とする平型半導体素子。

【請求項２】両側の電極板の一部をセラミックの絶縁環の外周より外側に延長した板状突起を有し、その板状突起を主電流端子とすることを特徴とする請求項１記載の平型半導体素子。

【請求項３】両側の電極板の延長部分の主電流端子の位置が互いにずらされていることを特徴とする請求項２記載の平型半導体素子。

【請求項４】両側の電極板の延長部分の主電流端子が、対称的な位置に設けられていることを特徴とする請求項３記載の平型半導体素子。

【請求項５】両側の電極板の延長部分の主電流端子が、互いに直角方向を向くように設けられていることを特徴とする請求項３記載の平型半導体素子。

【請求項６】電極板の延長部分の主電流端子に穴が設けられていることを特徴とする請求項１ないし５のいずれかに記載の平型半導体素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、電鉄用車両の主回路変換装置等に用いられ、大電流を制御する電力用の平型半導体素子に関する。

【０００２】

【従来の技術】図３は、従来の電力用の両面冷却型平型半導体素子の断面図である。図において、平型半導体素子１は、半導体素子チップ２を挟んで、その両側に伝熱部材３と電極板４とが配置され、加圧接触するようになっている。電極板４の周辺はアルミナの絶縁環５に固着され、半導体素子ケースが構成されている。伝熱部材３はシリコンと熱膨張係数の近い、例えばモリブデンであり、電極板４は電気、熱伝導度の大きい、例えば銅である。半導体素子チップ２で発生した損失熱は、熱伝導により伝熱部材３と電極部材４に伝えられ、電極部材４の表面に接する両側の冷却体へと放熱される。半導体チップ２の代わりに、タングステン等の耐熱金属板に合金した半導体エレメントを用いることもできる。なお、図では半導体チップ２を位置決めする手段等の詳細は省略されている。

【０００３】平型半導体素子の冷却方法については、冷却水（不凍液）を循環ポンプにより、半導体素子発熱面に装着した冷却体の内部流路に循環させ、半導体素子を冷却する循環水冷却方式がある。循環水冷却方式の冷却水媒体は、冷却水（不凍液）を用いている。他の冷却方式として、絶縁性冷媒（例えば、フロン液、或いはフッ化炭素液）の液中に半導体素子と冷却体とを浸漬させ、絶縁性冷媒の沸騰現象により半導体素子を冷却する浸漬沸騰冷却方式があるが、環境問題の配慮から絶縁性冷媒（例えば、フロン液、或いはフッ化炭素液）の使用を規制するという動きに対応して、循環水冷却方式を用いることが多くなっている。

【０００４】図４は、図３の平型半導体素子を用いた循環水冷却方式の構成を示す図である。平型半導体素子１と冷却体８とが交互に複数個直列配置され、加圧して半導体スタック１１が構成される。１４は加圧用の皿バネ、１５は均等加重するための鋼球である。その際に平型半導体素子１は、非絶縁性の冷却水（不凍液）と電気的に絶縁する必要があるため、平型半導体素子１と冷却水２１が通流する冷却体８との間には、平型半導体素子１に通電するための通電板１０および高熱伝導材料でできた絶縁板７が挟まれる。１２、１３はそれぞれ冷却水の分配用、集合用ヘッダである。平型半導体素子１で発生した損失熱は、平型半導体素子１から、通電板１０および絶縁板７を通して電気絶縁された冷却体８まで熱伝導で伝わる。この熱を、冷却体８内の流路に循環ポンプ１９により冷却水（不凍液）２１を循環させて強制対流熱伝達により除熱する。そして、最終的に空冷放熱器１６により、外気へと放熱を行うものである。１７は電動ファン、１８は冷却空気、２０は冷却水配管、２２はタンクである。

【０００５】

【発明が解決しようとする課題】図４に示した従来の平型半導体素子を用いた上記構成の半導体スタックでは、半導体素子と冷却体との間に絶縁板および通電板が存在する。従って半導体素子と冷却体との間には、半導体素子と通電板、通電板と絶縁板、絶縁板と冷却体と、三箇所の接触部があり、それぞれの箇所で接触熱抵抗が介在する。

【０００６】熱抵抗を実測したところ、一か所の接触部における接触熱抵抗の値は約０．０００１４Ｋ／Ｗで、電極板内部の熱伝導抵抗の値の２～３倍に相当しており、半導体素子と冷却体間の全体の熱抵抗０．０００５７Ｋ／Ｗの約２５％を占めていることがわかった。このような大きな熱抵抗は、冷却体および空冷放熱器の大型化を招くことになる。すなわち、電鉄用車両に搭載される主変換装置等における、寸法の小型化および重量の軽量化という課題に対して大きな障害となっている。

【０００７】以上の問題に鑑みて、本発明の目的は、冷却装置まで含めた組立状態での外形を小さくできる平型半導体素子を提供することにある。

【０００８】

【課題を解決するための手段】上記課題を解決するため本発明は、セラミックの絶縁環に固着された二枚の金属電極板をもち、収納された半導体エレメントの両面から放熱する両面冷却型の平型半導体素子において、少なく

とも一方の電極板の一部がセラミックケースの外周より外側に延長された板状突起を有し、その板状突起を主電流端子とするものとする。

【０００９】また、両側の電極板の一部をセラミックケースの外周より外側に延長した板状突起を有し、その板状突起を主電流端子としてもよい。電力用平型半導体素子の電極板を上記のように構成すれば、板状突起で、従来の通電板を兼ねることができるので、半導体素子スタックでの半導体素子と冷却体との間から通電板を削除できる。

【００１０】特に、両側の電極板の延長部分の主電流端子が対称的な位置、或いは互いに直角方向を向くなど、位置がずらして設けられていることがよい。そのようにすれば、主電流端子が互いに干渉することなく、外部導体との接続が容易である。更に、電極板の延長部分の主電流端子に穴が設けられているものとする。

【００１１】そのようにすれば、外部導体との接続が容易である。

【００１２】

【発明の実施の形態】図１（ａ）は、本発明の実施例の平型半導体素子の断面図、図１（ｂ）は図１（ａ）の平型半導体素子を図の左側から見た外形図である。図１（ａ）において、平型半導体素子１は、半導体素子チップ２を挟んで、その両側に伝熱部材３と電極板４とが配置され、加圧接触するようになっている。図の左側の電極板４ａの周辺にろう付けされた鉄－ニッケル合金の絞り板２５ａは、アルミナの絶縁環５にろう付けされている。図の右側の電極板４ｂの周辺にろう付けされた鉄－ニッケル合金の絞り板２５ｂと、アルミナの絶縁環５にろう付けされた鉄－ニッケル合金の溶接板２６とは、縁でアーク溶接されて、半導体素子ケースが構成されている。伝熱部材３はシリコンと熱膨張係数の近いモリブデンであり、電極板４は電気、熱伝導度の大きい銅である。チップ２で発生した損失熱が、熱伝導により伝熱部材３と電極板４に伝えられ、電極板４の表面に接する冷却体へと放熱されるのは、図４の従来の平型素子と同じである。

【００１３】図４の従来の平型半導体素子と異なる点は、半導体素子１の両面にある電極部材４の一部を半導体素子ケース５の外部より外側に延長させた板状突起を設け、電流端子６としている点である。電流端子６の幅と、厚さは、通電する電流容量、および接続されるブスによって決められる。この例では、半導体素子の両面の電極板４の電流端子６が、対称的な位置に設けられている。

【００１４】図１（ｂ）の外形図では、電極板４ａの一部に電流端子６が設けられている様子が見られる。そして、電流端子６には穴６１が開けられている。電極板４ａの周囲には絞り板２５ａが見られ、その外側には、絶縁環５が見える。図２は、本発明の平型半導体素子を用いた半導体スタックの部分構成図である。半導体素子１と冷却体８とが、窒化アルミニウムの絶縁板７を挟んで密着されている。スタック１１の端には、図４で示したように加圧のための皿バネや、均等加圧のための鋼球があるが、この図には示されていない。半導体素子１の電極板から延びた電流端子６と通電用の外部導体２３とが、ボルトナット２４で接続されている。９は冷却水である。

【００１５】この例では、従来の半導体スタック構成に比べて通電板が不要になり、半導体素子１と冷却体８の間の接触部が一か所削除されている。そのため、半導体素子１と冷却体８の間の熱抵抗が２５％低下した。その結果、同じ冷却条件で、通電電流を約１０％増大させることができた。逆に、同じ通電電流なら、循環水冷却方式の冷却装置の小型化が可能になる。

【００１６】半導体素子の両側の電流端子の方向としては、図１の実施例の他に、互いに直角方向を向くように設ける方法や、或いは同じ方向だが位置をずらす方法など、色々考えられる。また、角形の絶縁環をもつ平型半導体素子の例を示したが、角形に限られるものではなく、通常見られる円形の平型半導体素子にも適用できることは勿論である。

【００１７】

【発明の効果】以上説明したように、本発明の平型半導体素子は、電極板の一部が絶縁環の外周より外側に延長された板状突起を主電流端子とすることにより、冷却水（不凍液）を用いた循環水冷却方式による半導体素子スタックの構成において、従来の平型半導体素子を用いた半導体素子スタック構成の場合に比べ、半導体素子－冷却体間の熱経路上の接触箇所を一か所削減でき、半導体素子－冷却体間の熱抵抗を小さくできる。

【００１８】その結果、冷却体および空冷放熱器の形状を小さくでき、電鉄車両に搭載される主変換装置等の小型化軽量化に貢献できる。

【図面の簡単な説明】

【図１】（ａ）は本発明の実施例の平型半導体素子の断面図、（ｂ）はその外形図

【図２】本発明の平型半導体素子を用いた半導体スタックの部分構成図

【図３】従来の平型半導体素子の断面図

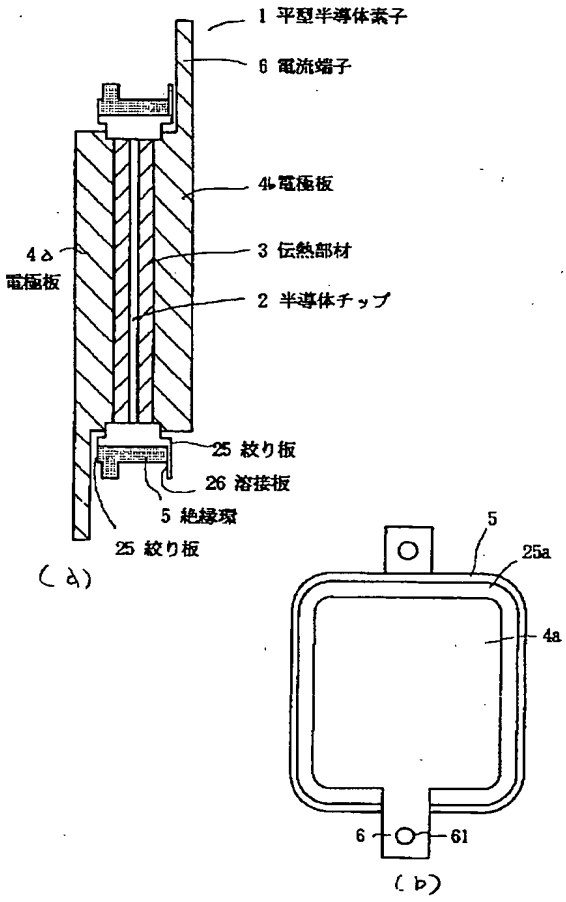
【図４】図３の平型半導体素子を用いた循環水冷却方式の構成図

【符号の説明】

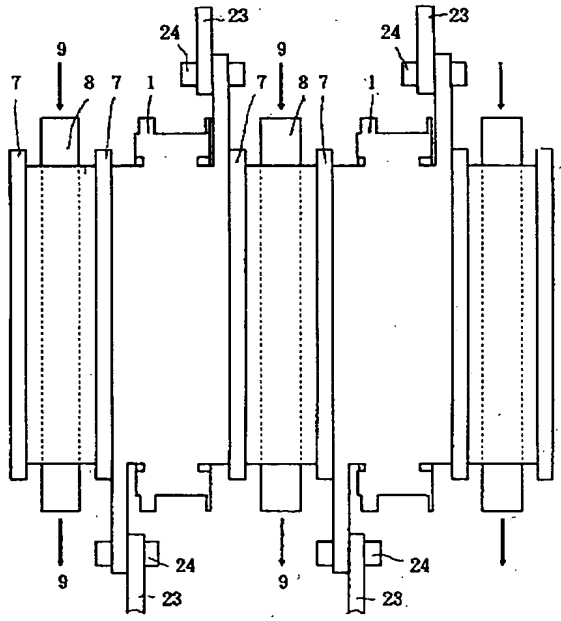
１	平型半導体素子
２	半導体チップ
３	伝熱部材
４	電極板
５	絶縁環
６	電流端子
６１	穴

7	絶縁板
8	冷却体
9	冷却水の流れ
１０	通電板
１１	スタック
１２	冷却水分配ヘッダー
１３	冷却水集合ヘッダー
１４	皿バネ
１５	鋼球
１６	空冷放熱器
１７	電動ファン
１８	冷却空気
１９	循環ポンプ
２０	液配管
２１	冷却水
２２	タンク
２３	外部導体
２４	ボルトナット

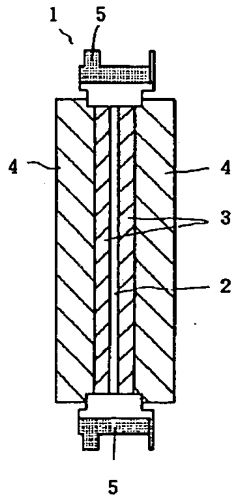
【図１】



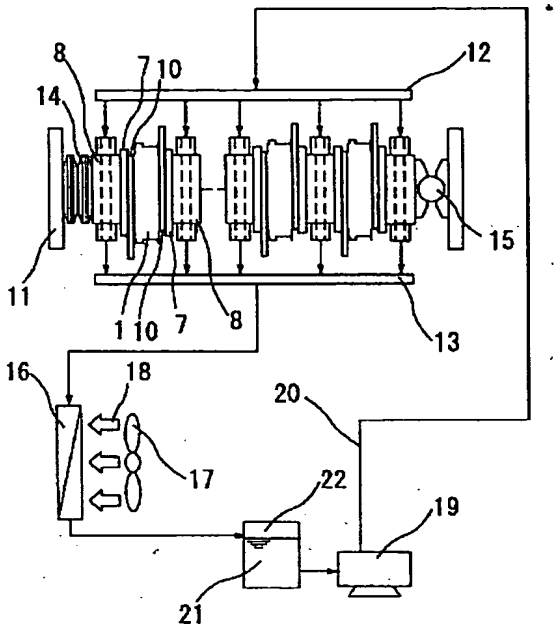
【図２】



【図３】



【図４】



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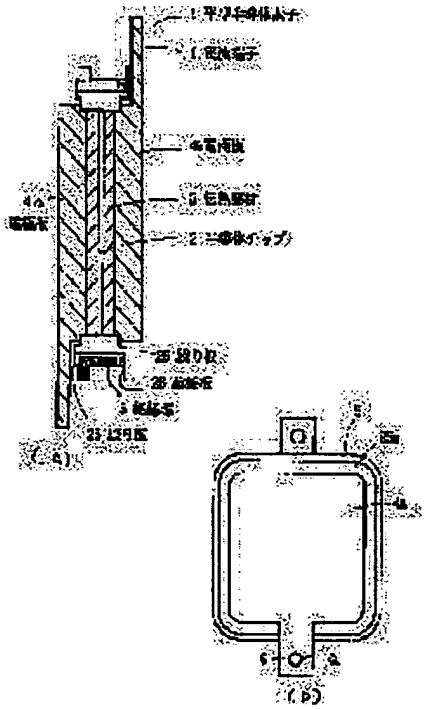
(57)Abstract:

PROBLEM TO BE SOLVED: To provide a flat-type semiconductor device which enables an electric power control device including a cooling device to be reduced in size and weight by reducing the thermal resistance between the semiconductor device and a coolant when a double-side cooling flat-type semiconductor is used in a circulating water cooling system.

SOLUTION: A plate-like protrusion is provided to the one end of each of the electrode plates 4a and 4b of a flat-type semiconductor device 1 extending outwards beyond the periphery of an insulating ring 5 to serve as a current terminal 6. A usual current plate can be dispensed with, so that a thermal resistance between the current plate and a contact can be eliminated. As compared with a conventional one, a thermal resistance between the flat-type semiconductor device 1 and a coolant can be reduced by 25%. It is preferable that the current terminals 6 are set deviating from each other in position so as not to impede their connection with outer conductors.



LEGAL STATUS

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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] A flat tip semiconductor device characterized by having a tabular projection by which some of one [at least] electrode boards were extended outside a periphery of an insulating ring in a flat tip semiconductor device of a double-side-cooling mold which has two metal-electrode boards which fixed to an insulating ring of a ceramic, and radiates heat from both sides of a contained semiconductor chip, and using the tabular projection as a principal current terminal.
[Claim 2] A flat tip semiconductor device according to claim 1 characterized by having a tabular projection which extended some electrode boards of both sides outside a periphery of an insulating ring of a ceramic, and using the tabular projection as a principal current terminal.
[Claim 3] A flat tip semiconductor device according to claim 2 characterized by shifting mutually a location of a principal current terminal of an extension of an electrode board of both sides.
[Claim 4] A flat tip semiconductor device according to claim 3 characterized by preparing a principal current terminal of an extension of an electrode board of both sides in a symmetrical location.
[Claim 5] A flat tip semiconductor device according to claim 3 characterized by being prepared so that a principal current terminal of an extension of an electrode board of both sides may turn to the direction of a right angle mutually.
[Claim 6] A flat tip semiconductor device according to claim 1 to 5 characterized by establishing a hole in a principal current terminal of an extension of an electrode board.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention is used for the main circuit inverter of the vehicles for electric railroads etc., and relates to the flat tip semiconductor device for power which controls a high current.
[0002]
[Description of the Prior Art] Drawing 3 is the cross section of the double-side-cooling mold flat tip semiconductor device for the conventional power. In drawing, the flat tip semiconductor device 1 sandwiches the semiconductor device chip 2, and the heat transfer member 3 and the electrode board 4 are arranged at the both sides, and it carries out pressurization contact. The circumference of the electrode board 4 fixes to the insulating ring 5 of an alumina, and the semiconductor device case is constituted. For example, silicon and a coefficient of thermal expansion are near, it is molybdenum and the electrode board 4 of the heat transfer member 3 is [the electrical and electric equipment and thermal conductivity are large, for example,] copper. The heat loss generated with the semiconductor device chip 2 is told to the heat transfer member 3 and the electrode member 4 by heat conduction, and radiates heat to the cooling object of the both sides which touch the surface of the electrode member 4. Instead of a semiconductor chip 2, the semiconductor element which carried out the alloy to heat-resistant metal plates, such as a tungsten, can also be used. In addition, details, such as a means to position a semiconductor chip 2 by a diagram, are omitted.
[0003] About the cooling method of a flat tip semiconductor device, the internal passage of the cooling object which equipped the semiconductor device exoergic side with cooling water (antifreezing solution) with the circulating pump is circulated, and there is circulating water cooling system which cools a semiconductor device. Cooling water (antifreezing solution) is used for cooling water data medium of the circulating water cooling system. Although there is immersion ebullition cooling system which a semiconductor device and a cooling object are made immersed into the liquid of an insulating refrigerant (for example, chlorofluocarbon liquid or carbon fluoride liquid), and cools a semiconductor device by bubbling of an insulating refrigerant as other cooling system, corresponding to the motion of regulating use of an insulating refrigerant (for example, chlorofluocarbon liquid or carbon fluoride liquid), the circulating water cooling system is used more often from consideration of an environmental problem.
[0004] Drawing 4 is drawing showing the configuration of the circulating water cooling system which used the flat tip semiconductor device of drawing 3 . Serial arrangement is carried out by more than one by turns, the flat tip semiconductor device 1 and the cooling object 8 pressurize, and the semiconductor stack 11 is constituted. The pan spring for pressurization in 14 and 15 are the shots for carrying out an equal load. Since it is necessary to insulate the flat tip semiconductor device 1 with the cooling water (antifreezing solution) of non-insulation electrically in that case, between the cooling objects 8 in which cooling water 21 carries out conduction to the flat tip semiconductor device 1, the electric insulating plate 7 made with the energization board 10 and high temperature conduction material for energizing to the flat tip semiconductor device 1 is inserted. 12 and 13 are an object for distribution of cooling water, and a header for a set, respectively. The heat loss generated in the flat tip semiconductor device 1 is transmitted from the flat tip semiconductor device 1 in heat conduction even to the cooling object 8 by which electric insulation was carried out through the energization board 10 and the electric insulating plate 7. The passage within the cooling object 8 is made to circulate through cooling water (antifreezing solution) 21 with a circulating pump 19, and this heat is cooled by heat transfer by forced convection. And finally heat is radiated to the open air with the air-cooling radiator 16. For 17, as for cooling air and 20, an electric fan and 18 are [cooling water piping and 22] tanks.
[0005]
[Problem(s) to be Solved by the Invention] In the semiconductor stack of the above-mentioned configuration using the conventional flat tip semiconductor device shown in drawing 4 , an electric insulating plate and an energization board

exist between a semiconductor device and a cooling object. Therefore, there are a semiconductor device, an energization board and an energization board, an electric insulating plate and an electric insulating plate, a cooling object, and the three contact sections between a semiconductor device and a cooling object, and it is placed between them by contact thermal resistance in each part.

[0006] When thermal resistance was surveyed, the values of the contact thermal resistance in the one contact section are about 0.0014 K/W, and it turned out that it corresponds by 2 to 3 times the value of the thermal resistivity inside an electrode board, and about 25% of thermal resistance 0.0057 K/W between [whole] a semiconductor device and a cooling object is formed. Such big thermal resistance will cause enlargement of a cooling object and an air-cooling radiator. That is, it has been a serious failure to a technical problem called the miniaturization of a size in the main converter carried in the vehicles for electric railroads, and lightweight-izing of weight.

[0007] The purpose of this invention is in view of the above problem to offer the flat tip semiconductor device which can make small the appearance in the assembly condition which even the cooling system included.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in a flat tip semiconductor device of a double-side-cooling mold which has two metal-electrode boards which fixed to an insulating ring of a ceramic, and radiates heat from both sides of a contained semiconductor element, this invention shall have a tabular projection by which some of one [at least] electrode boards were extended outside a periphery of a ceramic case, and shall use the tabular projection as a principal current terminal.

[0009] Moreover, it has a tabular projection which extended some electrode boards of both sides outside a periphery of a ceramic case, and is good also considering the tabular projection as a principal current terminal. If an electrode board of a flat tip semiconductor device for power is constituted as mentioned above, since it can serve as the conventional energization board, an energization board can be deleted from between a semiconductor device in a semiconductor device stack, and cooling objects by tabular projection.

[0010] It is [a location where a principal current terminal of an extension of an electrode board of both sides is symmetrical especially, or for a location to shift and to prepare it] good to turn to the direction of a right angle mutually etc. Connection with an outer conductor is easy, without a principal current terminal interfering mutually, if it is made such. Furthermore, a hole shall be established in a principal current terminal of an extension of an electrode board.

[0011] If it is made such, connection with an outer conductor is easy.

[0012]

[Embodiment of the Invention] It is outline drawing with which drawing 1 (a) looked at the cross section of the flat tip semiconductor device of the example of this invention, and drawing 1 (b) looked at the flat tip semiconductor device of drawing 1 (a) from the left-hand side of drawing. In drawing 1 (a), the flat tip semiconductor device 1 sandwiches the semiconductor device chip 2, and the heat transfer member 3 and the electrode board 4 are arranged at the both sides, and it carries out pressurization contact. Throttle plate 25a of the iron nickel alloy soldered around electrode board 4a on the left-hand side of drawing is soldered at the insulating ring 5 of an alumina. The arc welding of throttle plate 25b of the iron nickel alloy soldered around electrode board 4b on the right-hand side of drawing and the welding board 26 of the iron nickel alloy soldered at the insulating ring 5 of an alumina is carried out on the edge, and the semiconductor device case is constituted. The heat transfer members 3 are silicon and molybdenum with a near coefficient of thermal expansion, and the electrode boards 4 are the electrical and electric equipment and copper with large thermal conductivity. It is the same as the conventional flat tip element of drawing 4 to radiate heat to the cooling object with which the heat loss generated with a chip 2 is told to the heat transfer member 3 and the electrode board 4 heat conduction, and touches the surface of the electrode board 4.

[0013] A different point from the conventional flat tip semiconductor device of drawing 4 is a point which prepares the tabular projection which made a part of electrode member 4 in both sides of a semiconductor device 1 extend outside the exterior of the semiconductor device case 5, and is used as the current terminal 6. The width of face of the current terminal 6 and thickness are decided by the current capacity to energize and Bus connected. In this example, the current terminal 6 of the electrode board 4 of both sides of a semiconductor device is formed in the symmetrical location.

[0014] In outline drawing of drawing 1 (b), signs that the current terminal 6 is formed in a part of electrode board 4a are seen. And the hole 61 has opened in the current terminal 6. Throttle plate 25a is seen around electrode board 4a, and the insulating ring 5 is visible to the outside. Drawing 2 is the partial block diagram of the semiconductor stack which used the flat tip semiconductor device of this invention. On both sides of the electric insulating plate 7 of alumimium nitride, it is stuck to the semiconductor device 1 and the cooling object 8. Although there are a pan spring for pressurization and a shot for equal pressurization in the edge of a stack 11 as drawing 4 showed, it is not shown in this drawing. The current terminal 6 prolonged from the electrode board of a semiconductor device 1 and the outer conductor 23 for

energization are connected with the bolt nut 24. 9 is cooling water.
[0015] In this example, compared with the conventional semiconductor stack configuration, an energization board becomes unnecessary, and the one contact section between a semiconductor device 1 and the cooling object 8 is deleted. Therefore, the thermal resistance between a semiconductor device 1 and the cooling object 8 fell 25%. Consequently, energization current was able to be increased about 10% on the same cooling conditions. On the contrary, if it is the same energization current, the miniaturization of the cooling system of the circulating water cooling system is attained.
[0016] the method of establishing as a direction of the current terminal of the both sides of a semiconductor device, so that the direction of a right angle other than the example of drawing 1 may be turned to mutually -- or the way the same rudder shifts a location etc. is considered variously. Moreover, although the example of a flat tip semiconductor device with the insulating ring of a square shape was shown, of course, it is applicable also to the circular flat tip semiconductor device which is not restricted to a square shape and is usually seen.
[0017]
[Effect of the Invention] As explained above, the flat tip semiconductor device of this invention By using as a principal current terminal the tabular projection by which some electrode boards were extended outside the periphery of an insulating ring In the configuration of the semiconductor device stack by the circulating water cooling system using cooling water (antifreezing solution) Compared with the case of the semiconductor device stack configuration using the conventional flat tip semiconductor device, one contact part on the heat path between semiconductor device-cooling objects can be reduced, and thermal resistance between semiconductor device-cooling objects can be made small.
[0018] Consequently, the configuration of a cooling object and an air-cooling radiator can be made small, and it can contribute to miniaturization lightweight-ization of the main converter carried in electric railroad vehicles.

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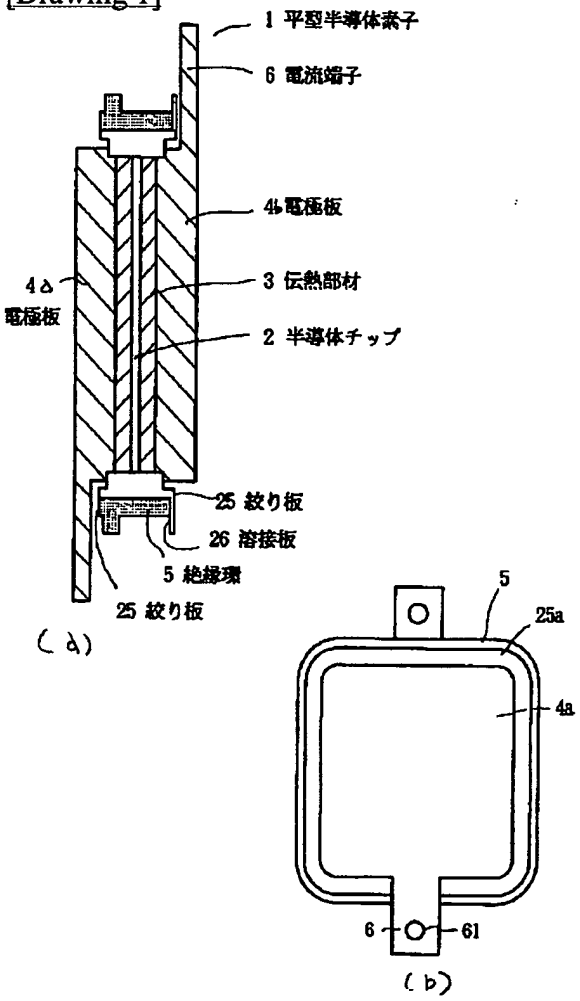
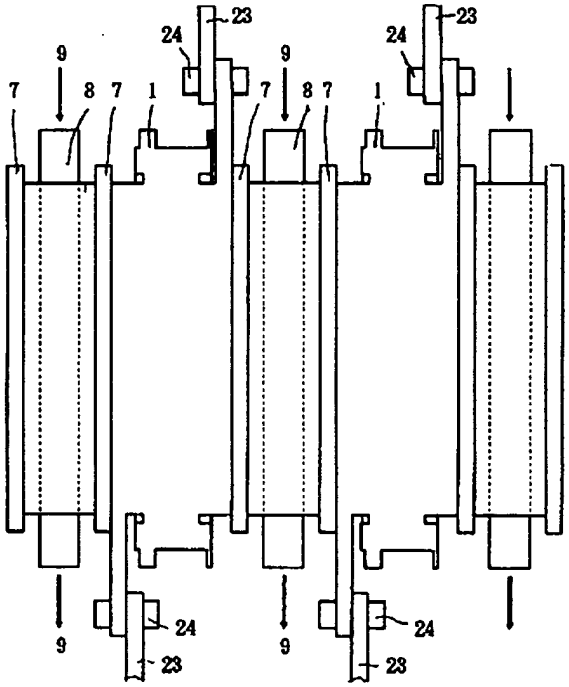
DRAWINGS

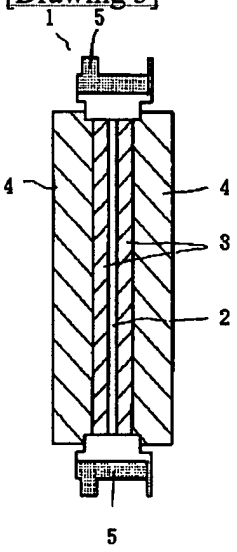
[Drawing 1]



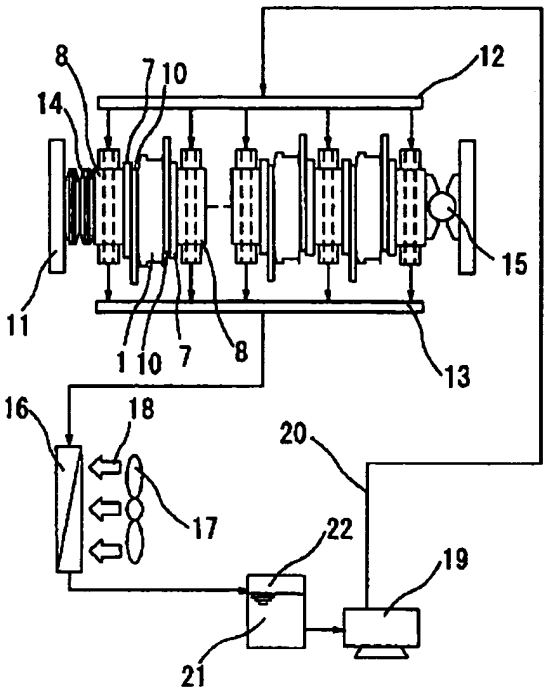
[Drawing 2]



[Drawing 3]



[Drawing 4]



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